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Improvement of Arecanut

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1. INTRODUCTION

Arecanut is one of the very few examples, wherein crop improvement work combined with improved input technologies contributed to revolutionalise the production and productivity within the last 30 years. Prior to initiating research on crop improvement, arecanut production in India was around 76,000 tonnes (1956-57). Research efforts by way of improved varieties and associated technology developed at the research institute combined with developmental activities had considerable impact on increasing the production to 1,91,400 tonnes in 1980-81 and to 2,46,100 tonnes in 1988-89. The productivity increased from 788 kg during 1956-57 to 1205 kg during 1988-89. Thus, the increase in production was not only due to increased area under culitvation but also increased productivity contributed by superior varieties, supply of quality planting materials, better agro-techniques and plant protection.

Evolution of improved varieties in arecanut has been achieved through the introduction of indigenous and exotic types and refinement of selection procedures in mother-palms, seednuts and seedlings.

2. CROP IMPROVEMENT

2.1 Introduction

Arecanut has habitat in Malay penninsula, Thailand and neighbouring islands (Blume, 1836). This crop is found naturally occurring in Indonesia, the Philippines, South China and in all parts of the East Indies also. Besides, the cultivars of arecanut a number of related species of *Areca* have also been reported from these countries/islands (Bavappa, 1963). The Central Arecanut Research Station, Vittal (at present the Regional Station of CPCRI) initiated collection and maintenance of arecanut germplasm right from its inception during 1957. A collection of 45 indigenous types of arecanut obtained from different parts of India as well as other arecanut growing countries such as Sri Lanka, the Philippines, Indonesia, Singapore, Malaysia, Thailand, Solomon Island, Fiji, South China and Mauritius are being maintained at Regional Station, Vittal. In addition, the centre also maintains a live herbarium of 23 exotic types belonging to six species of *Areca*.

2.2 Selection

Comparative trial of 16 cultivars was initiated in the early 60's and yield evaluation for nine years (Anonymous, 1974) indicated that five introductions namely VTL-3, VTL-11, VTL-12, VTL-13 and VTL-17 have high yield potential in comparison with the local cultivar, South Kanara. Among them, VTL-3, an introduction from South China, (Anonymous 1972) has a number of desirable characters such as earliness in bearing, more number of female flowers per inflorescence, high nut set, initial and cumulative higher yields, quicker stabilisation of production and lower height in comparison with the South Kanara cultivar (Table 1). This semi-tall cultivar recommended for release in 1971 (Anonymous, 1972) for general cultivation under the name MANGALA, is characterised by partially drooping crown with well spread leaves and having more number of leaflets in comparison with South Kanara cultivar (Fig. 1). The leaflets are dark green in colour with characteristic crinkling at the tip (Bavappa, 1977).

Table 1 : Comparative yield of Mangala

Cultivars	Wet weight of nuts/palm/year (kg.)					
	1971-72	1972-73	1973-74	1974-75	1975-76	Total
Mangala	4.73	16.75	12.36	16.04	14.15	64.03
South Kanara	1.57	4.80	5.11	6.62	8.89	26.99

Based on the subsequent yield performance, two cultivars namely VTL-11 and VTL-17 were released for general cultivation during the year 1985. A brief description of VTL-11 (Sumangala) (Fig. 2) and VTL-17 (Sreemangala) (Fig. 3) are given below:

Sumangala (VTL-11): Sumangla is an introduction from Indonesia. Palm is tall with partially dropping habit. Under ideal condition, palm flowers in 4-5 years. The colour of the ripe nuts is deep yellow to orange and oblong to round in shape. Sumangala gives an average yield of 17.25 kg of ripenuts per plam per year at the age of 10 years. The variety has been recommended for commercial cultivation during the year 1985 based on the performance over 10 years in all the arecanut growing areas in general, and Dakshina Kannada in particular.

Sreemangala (VTL-17): The variety was selected from an introduction from Singapore. Palm is tall with partially drooping habit and comes to flowering in the fifth year. It is a high yielder with an average yield of 15.63 kg/palm/year. Ripe nuts are oblong to round with deep yellow colour. This variety has been recommended for general cultivation in Karnataka during the year 1985.

The comparative yield performance of Sumangala and Sreemangala along with Mangala and South Kanara are given in Table 2. There is an increase in the yield of 63 per cent and 48 per cent respectively for Sumangala and Sreemangala over the South Kanara variety and 53 per cent and 39 per cent more yield over Mangala.

Fig. 1 : VTL 1. Mangala.

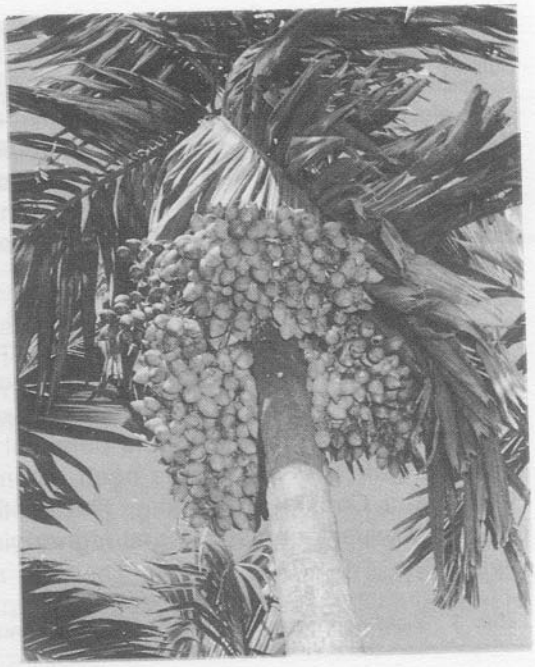

Fig. 2 : VTL 2 Sumangala.

Fig. 3 : VTL 3 Sree Mangala.

Fig. 4 : Mohit Nagar.

Table 2 : Yield performance of arecanut cultivars (1968-'78)

Cultivar	No. of palms	Mean yield No./palm/year	Wt. of nuts palm/year	% over Local	VTL-3
Mangala	6	299.58	11.25	6.23	—
Sumangala	6	606.21	17.25	62.89	53.33
Sreemangala	6	413.79	15.63	47.59	38.93
Local (South Kanara)	6	296.67	10.59	—	—

The indigenous collections of 13 cultivars from Thirthahalli, Chickmangalur, Hirehalli, Peechi, Mohitnagar, Assam, South Kanara and Gujarat were under comparative evaluation from 1964 onwards and four more types were added fro the evaluation from Sreevardhan, Dapoli, Thirthahalli and Assam during 1966. The yield evaluation of these cultivars indicated the high yield potential of Mohitnagar, an indigenous cultivar from West Bengal. The variety has been recommended for release during 1991 for North Bengal and Coastal Karnataka. The striking features of this variety are, its greater uniformity wider adaptability and higher yield of about 15.0 kg of ripe nuts/palm/year (Table 3).

Table 3 : Yield performance of 'Mohitnagar' arecanut variety

	Mangala	Sumangala	Sreemangala	Mohitnagar
Mean yield/palm/year (fresh wt. in Kg.)	8.82	12.93	12.82	15.08
Mean chali yield/ palm/year in Kg.	2.02	3.28	3.10	3.67
% increase in yield of Mohitnagar cultivar	70.98	16.63	17.63	—

3. SELECTION OF SEEDLINGS AND MOTHER PALM

3.1 Seedling Selection

Judicious selection of arecanut seedlings at the time of planting has resulted in considerable increase in yield of plantation established (Bavappa and Ramachander, 1967a; Bavappa, 1970). Among the various seedling characters correlated with heritability at other attributes, it was found that the number of leaves at the time of planting, grith and collar one year after planting and number of nodes two years after planting have positive genotypic and phenotypic correlations with yield and high heritability. All these three characters have negative correlation with age at first bearing indicating that selection of seedlings based on these characters would come to bearing earlier than the bulk planting. Based on these studies a standard for seedling selection has been established which consists of selecting seedlings with four or more number of leaves, 20 cm or more girth at collar after one year and four or more number of nodes two years after planting (Bavappa and Ramachader, 1967a, 1967c). Bavappa (1970) also suggested selection

of seedlings with maximum number of leaves and minimum height for transplanting in the main field. A simple selection formula was computed by him based on number of leaves present at the time of planting to be multiplied by 40 and subtracting the height of the seedlings. Seedlings having higher values based on this computation are to be selected for establishing high yielding plantations.

3.2 Mother Palm Selection

Bavappa and Ramachander (1967c) observed that the progeny performance had no relation with the regularity in yielding behaviour of the mother palms. Further it was also observed that mother plams having high progeny performance were distributed in almost all the gardens and hence giving emphasis for selection of seednuts from a particular garden as practised by the farmers has no scientific validity (Bavappa and Ramachander, 1967c, Anonymous, 1969a).

Yield pattern of the palms of different bearing ages indicated that palms which come to bearing earlier are always better yielders (Bavappa and Ramachander 1967c; Table 4). They also observed that selection of seedlings for number of leaves, girth at collar and number of nodes as per standard fixed (detailed earlier) totally eliminated

Table 4 : Effect of selection of seedlings on age at first bearing

Age at first bearing in years	Percentage of plams in different age groups	
	Before selection	After selection
5	62	74
6	32	25
7	4	1
8	1	0
9	1	0

late bearing plams in a garden established with such seedlings. Bhagwan *et al.* (1981) showed that selection based on yield alone may not be worth practising since heritability values for the number of nuts and weight of nuts are very low (Table 5).

3.3 Mass Pedigree Selection

A modified mass pedigree selection was initiated by Bavappa and Ramachander (1967c; 1968a; 1968b) with the primary objective of attainment of increase in yield. A garden was established with about 3,000 palms selected from 41 families from the farmers, garden. Families and palms within the selected families were screened by applying bulk and individual norm tests (Harland, 1957). The screening resulted in selection of 10 palms belonging to three families and the s :cond generation garden established from the progenies of these selected palms indi :ated that the expected genetic gains for wet weight of nuts were very low as well as for the number of nuts. It was concluded that such a selection procedure of applying bulk norm and individual

Table 5 : Heritability estimates for various characters

Characters	Heritability	
	Unselected nuts	Selected nuts
Seed weight	0.14	0.33
Germination	0.53	0.65
Girth	0.08	0.25
Height	0.59	0.58
Number of leaves	0.23	0.23
Age at flowering	0.15	0.26
Number of nuts	0.06	0.25
Weight of nuts	0.08	0.29

norm testing as in the case of cotton is ineffective in improving arecanut yield (Anonymous, 1981).

Bavappa and Ramachander (1967b) suggested a refinement of selection procedure superimposing characters of high heritability and correlation with yield, prepotency, selection index and desirable characters such as resistance to pests and diseases in addition to the bulk norm test and single norm test. However, this hypothesis is yet to be put into practice to find out the advantages of such a selection procedure.

4. CORRELATION AND HERITABILITY

Genotypic correlation worked out by Bavappa and Ramachander (1967a) with yield during the first 4 years of bearing of a plantation showed significant positive correlation with yield existed for the number of leaves at the time of planting, girth collar one year after planting and number of nodes two year after planting (Table 6). As the heritability for yield in arecanut is very low (0.20) practically no improvement in yield could be achieved by direct selection for this character (Bavappa and Ramachander 1967c; Table 7). Among various characters considered, age at first bearing alone was found to have high heritability and correlation with yield followed by percentage of inflorescence of leaves shed. Though the percentage of nut set is highly correlated with yield, heritability was found to be relatively low (Bavappa and Ramachander 1967c; Anonymous 1969b).

5. SELECTION INDEX

An attempt to refine selection method was made by Ramachander and Bavappa (1972) adopting selection index technique. For this 17 growth measurements taken at various stages of growth along with 12 yield components were used. Selection index based on 17 growth measurements gave an efficiency of 476 per cent over straight

Table 6 : Phenotypic and genotypic correlations between morphological characters of seedlings and their subsequent yield

Morphological characters	Phenotypic correlation with yield during				Genotypic correlation with yield during				Heritability
	First year	Second year	Third year	Fourth year	First year	Second year	Third year	Fourth year	
I year (at the time of planting)									
Number of leaves	0.21**	0.04	0.04	0.04	0.32*	0.12	0.21	0.39**	0.92
Girth at collar	0.12	0.04	0.03	0.05	0.12	−0.35*	−0.40**	−0.16	0.96
Height	0.19*	0.06	0.06	0.06	0.36*	−0.18	−0.18	−0.15	0.80
II year (one year after planting)									
Number of leaves	0.26**	0.17*	0.12*	0.09*	0.98**	−0.32*	−0.08	−0.01	0.32
Girth at collar	0.21**	0.27**	0.16*	0.23**	0.46**	0.10	0.16	0.28*	0.80
Height	0.22**	0.27**	0.22*	0.19**	0.31*	−0.25	−0.41**	−0.27	0.32
III year (two years after planting)									
Number of leaves	0.24**	0.13*	0.15*	0.26*	0.19	−0.08	−0.09	0.14	0.32
Girth at permanent mark	0.16*	0.17*	0.14*	0.16*	−0.15	0.68**	0.45**	0.36	
Girth at last exposed node	0.19*	0.09	0.23**	0.13**	0.33*	−0.03	0.21	0.25	0.64
Number of nodes	0.20**	0.26**	0.13*	0.17*	0.39**	0.28*	0.03	0.12	0.96

*Above P 0.05 level of significance : 0.10
**Above P 0.01 level of significance : 0.20

*Above P 0.05 level of significance : 0.28
**Above P 0.01 level of significance : 0.38

Table 7 : Correlation of different characters with yield (number of nuts) and their heritability

Characters	Correlations			
	Phenotypic	Genotypic	Environmental	h^2
Age at first bearing	–0.45	–0.55	–0.65	0.72
Number of leaves shed	0.19	0.53	0.35	0.32
Number of inflorescences produced	0.41	0.02	0.59	0.46
Number of bunches harvested	0.72	0.27	0.77	0.10
Number of female flowers produced	0.55	–0.44	0.65	0.08
Number of nuts set	0.97	1.08	0.97	0.03
Percentage of nut set	0.78	0.88	0.75	0.33
Mean weight	–0.28	–0.58	–0.24	0.07
Number of nuts per bunch	0.84	0.86	0.82	0.22
Percentage of bunches to inflorescences	0.60	0.42	0.63	0.16
Percentage of inflorescences to leaves shed	0.42	0.04	0.69	0.60

selection based on yield indicating significance of growth measurements over the yield components. They also worked out a simple index using only two characters, viz., number of leaves and height at the time of transplanting, which gave genetic advancement of 190 per cent and relative improvement of 332 per cent (Bavappa, 1970; Ramachander and Bavappa 1972).

6. HYBRIDISATION

Hybridisation programme in arecanut was initiated in early 70's at CPCRI Regional Station, Vittal, with the specific objective of (1) evolving varieties with high yield and regular bearing, (2) combining large sized fruit with more of nuts per bunch, (3) high yield of Mangala with quality of Sreevardhan, (4) transferring more number of female flowers and high percentage of seed set from *A. triandra* and (5) studying the combining ability for exploitation of hybrid vigour. Distribution of desirable characters in different accessions of *Areca catechu* and related species is indicated in Table 8. Inter-varietal hybridization carried out among Mangala, VTL-11, VTL-13, VTL-17, Mohitnagar, Tirthahalli and Dwarfs and evaluation of hybrid seedlings with respect to their performance did not result in selecting any useful arecanut hybrids so far. However, utilization of the Dwarf mutant seems to be encouraging and attempt in this direction to establish plantation with short-statured plams is in progress.

Bavappa (1974) reported detailed morphological and cytological investigation of the reciprocal hybrids of *A. catechu* and *A. triandra*. Further studies (Bavappa, 1974; Bavappa and Nair, 1975) showed that *A. catechu* × *A. triandra* hybrid expressed hybrid vigour for number of male flowers, length of spadix and girth of stem at fixed mark etc. (Table 9). However, such hybrids showed high sterility and efforts to evolve better varieties combining qualities of *A. catechu* and *A. triandra* have not become successful so far.

Table 8 : Distribution of characters in different accessions

Characters	Probable donors
High yield	*A. catechu* 'Singapore'
	A. catechu Mangala
Early bearing	*A. catechu* Mangala
Greater number of fruits/bunch	*A. catechu* 'Thirthahalli'
Better quality	*A. catechu* 'Sreevardhan'
Fruit size (large)	*A. catechu* 'South Kanara'
Regular bearing	*A. catechu* 'South Kanara'
Dwarfness	*A. catechu* Dwarf mutant
More number of female flowers per bunch	*A. triandra*
High percentage of fruit set and suckering habit	

Table 9 : Morphological characteristics of *A. triandra* and their hybrids

Characters	*A. catechu*	*A. catechu* × *A. triandra*	*A. triandra* × *A. catechu*	*A. triandra*
Number of stems	1	1	9.5±3.1	9.8±2.9
Internodal distance at fixed mark (cm)	11.4±3.3	19.8±2.4	16.0±1.7	13.6±3.6
Girth of stem at fixed mark (cm)	45.3±4.4	39.0±0.70	24.1±0.4	18.2±1.2
Number of leaves/clump	9.5±0.3	9.5±0.3	35.0±3.4	51.4±14.4
Mean length of spadix (cm)	56.3±2.9	87.8±2.6	50.3±1.2	43.0±2.3
Number of female flowers/bunch	386.3±36.4	2856.8±340.3	409.8±64.6	588.2±133.4
Mean length × breadth of female flowers (cm)	1.76×1.02	1.13×0.52	0.83×0.05	0.84×0.46
Number of male flowers/bunch	33321±5080	488856±3868	29682±4027	27083—3191
Mean length × breadh of male flowers (cm)	0.44×0.23	0.26×0.12	0.24×0.10	0.22×0.10
Number of stamens	6, occasionally 5	3-5	3	3
Arrangement of male flowers	Single, biseriate, alternate	Paired, biseriate, alternate	Paired, uniseriate	Paired, uniseriate
Mean length × breadh of fruit	5.3×4.2	4.2×2.1	2.9×1.44	2.7×1.5
Maturity period of nuts (days)	287±16	298±19	162±1	163±8
Pollen stainability	93.0±3.5	4.7±1.7	67.0±6.4	56.5±7.6

7. SEED : DEMAND AND PRODUCTION

Though the National Commission on Agriculture had anticipated the country's arecanut requirement at 1,90,000 tonnes by the end of the century, the production at present has already exceeded by 60,000 tonnes. The arecanut price is still very attractive and fresh plantations are being established by farmers enthusiastically.

The demand for quality planting material in arecanut is ever on the increase and the Central Plantation Crops Research Institute has received indents for 2 million seednuts/seedlings for the 1993 planting season in four released varieties. As the seedling demands are from Kerala and Karnataka, the anticipated area expansion in these two states together annually is about 1500 ha. During the last two decades (70-71 to 90-91) the area under arecanut in the country has been increasing at the rate of 2000 ha annually. This means for area expansion alone the country needs about 2.6 million seedlings annually at the rate of 1300 seedlings/ha.

A comprehensive survey conducted by CPCRI during 1991-92 in Karnataka revealed that the yellow leaf disease is prevalent in Dakshina Kannada, Kodagu, Chickmagalur, Shimoga and Uttara Kannada districts and out of 6.59 million arecanut palms in these districts, 0.77 million palms are affected by the disease.

A survey conducted in 1976 in Kerala indicated that out of 92,680 ha of areca plantations in Kerala about 36 per cent or roughly about 33,000 ha were affected by the disease. The disease has been spreading eversince and the area under arecanut has now dwindled to 62,100 ha (1990-91) in the state. Though accurate figures are not available, assuming that the percentage of the disease incidence is almost same in the state, it can be inferred that about 22,500 ha are affected by the disease (approximately 29 million palms). The investigation on the etiology of the disease has indicated that the disease is caused by mycoplasma like organisms (MLOs). Eradication of the disease affected palms and replanting with the healthy seedlings, are the recommendation at present to contain the disease. The total numbers of healthy seedlings required for replanting the disease affected area in Karnataka and Kerala can be estimated as follows:

Karnataka—600 ha or 0.7 million seedlings
Kerala—22500 ha or 29.0 million seedlings
Total : 29.7 million seedlings

Assuming that the replanting programme can be taken up in a phased programme of 10 years, the annual seedlings requirement for replanting will be 2.97 million. Thus the annual seedlings requirement of the country for area expansion and replanting will be:

i) Area expansion—new planting (2000 ha)	:	2.60 million
ii) Replanting disease affected areas (2250 ha)	:	2.97 million
Total	:	5.57 million

8. PRODUCTION OF PLANTING MATERIAL

The only arecanut seed garden in the country is at CPCRI, Seed Farm, Kidu, Karnataka, established between 1972 and 1976. Isolated blocks of Mangala, Sumangala, Sreemangala and Mohitnagar were established with open pollinated seeds obtained from the original introduction at CPCRI Regional Station, Vittal. The 'off-types' found in the

seed garden in each of the varieties can be attributed to the original source of open pollinated seedlings. In recent years all the 'off-types' were marked and uprooted to ensure natural production of pure seeds through selfing or *inter se* mating. A higher proportion of segregates was observed in Mangala than in other three released varieties. In view of this, a secondary selection programme has been initiated by establishing seed garden utilizing *inter se* seed nuts in each of the variety. This programme is expected to help in maintaining varietal purity in the four released varieties. To establish seed gardens in Kerala, Karnataka and Assam it is proposed to use seeds from *inter se* mating from the secondary selection blocks.

Assuming that a palm would yield about an average of 150 seednuts per annum, to meet the requirement of 5.57 million seed nuts annually, seed garden consisting of 37,500 mother plams or about 30 ha are to be established in the country. In other words only 10 ha of seed gardens need to be established in each of the three leading arecanut producing states. The Directorate of Cocoa and Arecanut has to come forward to establish the seed gardens during the VIII Plan period to meet this requirement. The elite planting materials in the released varieties and technical support are to be given by the Central Plantation Crops Research Institute.

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